Collision Avoidance Subcommittee Update

CA Meeting #34 18-Apr-2024
1:30 pm – 4:30 pm ~3hrs

Darren Aklestad - SLB
17 Apr 2024

- Darren Aklestad
- 33 yrs Schlumberger/SLB
- Wellbore positioning, well planning, anti-collision, cartographic systems, survey corrections
- Aklestad@slb.com

SPE ACR Adoption Status / Rev 5

- 34 Attendees (11 Online) (45 total)
  - 30 companies (10 Operators,17 Service Providers,4 Software vendors)
- Using WPTS AC Rule - 16 yes (previous meeting 6)
- Using ISCWSA Rev 5 Error Model – 16 yes

Agenda Covered

1. Quick Review of previous meeting work
2. Inferred un-surveyed vertical well error model - Kevin Sutherland CVX - presentation/discussion
3. WPTS Surface Margin – Bill Allen BP - presentation/discussion
4. Jerry Codling HAL – Probability of Wellbore Intercept Made Easy - presentation/discussion
5. Probability of Collision (PC) – discussion

WPTS Collision Rule – Committee Recommendation

- WPTS Rule is accepted (re-re-analyzed) as correct and appropriate
- The published values of Sm & Pa are also accepted as appropriate
- The WPTS rule should be the primary rule used
- If WPTS rule fails and with further investigation of specific drilling circumstances – a modified version can be employed
  - The Sm & Pa constants may be adjusted as needed for specific drilling circumstances – even to zero.
  - Re-use of previous separate surface rule may be appropriate – only after specific situation investigation another means of accounting for surface collision avoidance mitigation
- White paper will be published on the website as an addendum to the rule
- Possible update concerning Pa – work ongoing (Marc Willerth H&P)

Final Revised Table Recommendation & RP78 Inclusion

Separation Factor (SF)	Planned Steering Yield or Expected Dogleg Severity (DLS) [°/100 ft MD]		
	DLS ≤ 2°/100 ft DLS ≤ 2°/30m Very Long Radius / Tangent Interval	2° < DLS ≤ 6°/100 ft 2° < DLS ≤ 6°/30m Long Radius / Steered Interval	DLS > 6°/100 ft DLS > 6°/30m Medium Radius / Steered Interval
SF > 4.0	200 ft (60 m)	100 ft (30 m)	100 ft (30 m)
1.5 < SF ≤ 4.0	140 ft (42 m)		
SF ≤ 1.5			45 ft (14 m) or DP joint length

Note: The preceding table is intended as general guidance for determining survey intervals that ought not exceed minimum regulatory requirements for spacing between surveys for vertical, directional, and horizontal wells. As additional wellbores may be added in the future, it is also recommended that exploration wells and other stand-alone wells adhere to these guidelines.

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Inferred un-surveyed vertical wells

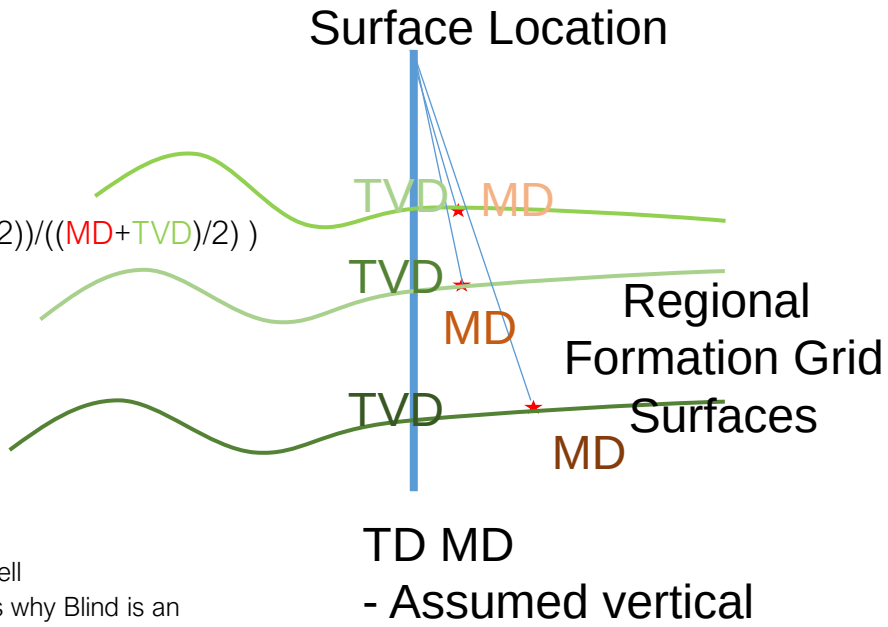
- Kevin Sutherland (CVX) taken over from Pete Clark
- Presentation will be posted to the ISCWSA.net website
- Will join EM group to add CVX procedure for analysis and EM selection

Inferred Wellbore Position - Challenge

- Challenge
  - Many downhole wellbore positions defined by
    - Surface location
    - TD MD
  - No directional survey information
- Leads to
  - Assign “Blind” positional uncertainty model
  - ~46° cone
  - at TD error radius is greater than depth
    - Additional cost due to directional drilling to avoid possible well’s placement
    - Inefficiency risk assessing potentially unlikely well collision
      - Discount Blind wells as no risk

Inferred Wellbore Position – Proposal

- From existing measurements & models
  - Calculate TVD for formation grid using
    - Surface location
    - Regional formation top surfaces
  - Compare recorded top MD to projected TVD
    - Calculate **Sustained Inclination (SustInc)**
      - **SustInc** = ArcTangent(SQRT(ABS(MD^2-TVD^2))/((MD+TVD)/2))
      - If **SustInc** < 5°
        - Assign "Inc-Only-Planned" PU model
        - ~7.46° cone @ 3σ : 63_Inc-Only-Plan
      - If 5° ≤ **SustInc** < 10°
        - Assign "Inc-Only-Planned-10" PU model
        - ~14.67° cone @ 3σ : 72_Inc-Only-Plan_ST
      - If **SustInc** ≥ 10°
        - Assign "Blind" PU model : 60_Blind
        - Not credible to consider this as a near vertical well
        - Means there's no surveys for a deviated well & is why Blind is an appropriate model



Inferred Wellbore Position - Proposal

- ~~Form a CA sub-committee work group~~ Append to EM work group
  - Kevin & Harald Bolt
- Review this proposal
- Alternate approaches
- Optimize method
- Identify issues
- Produce guidance
  - To include the statement that good surveying practices should always be employed and resurveying wells missing surveys is best practice

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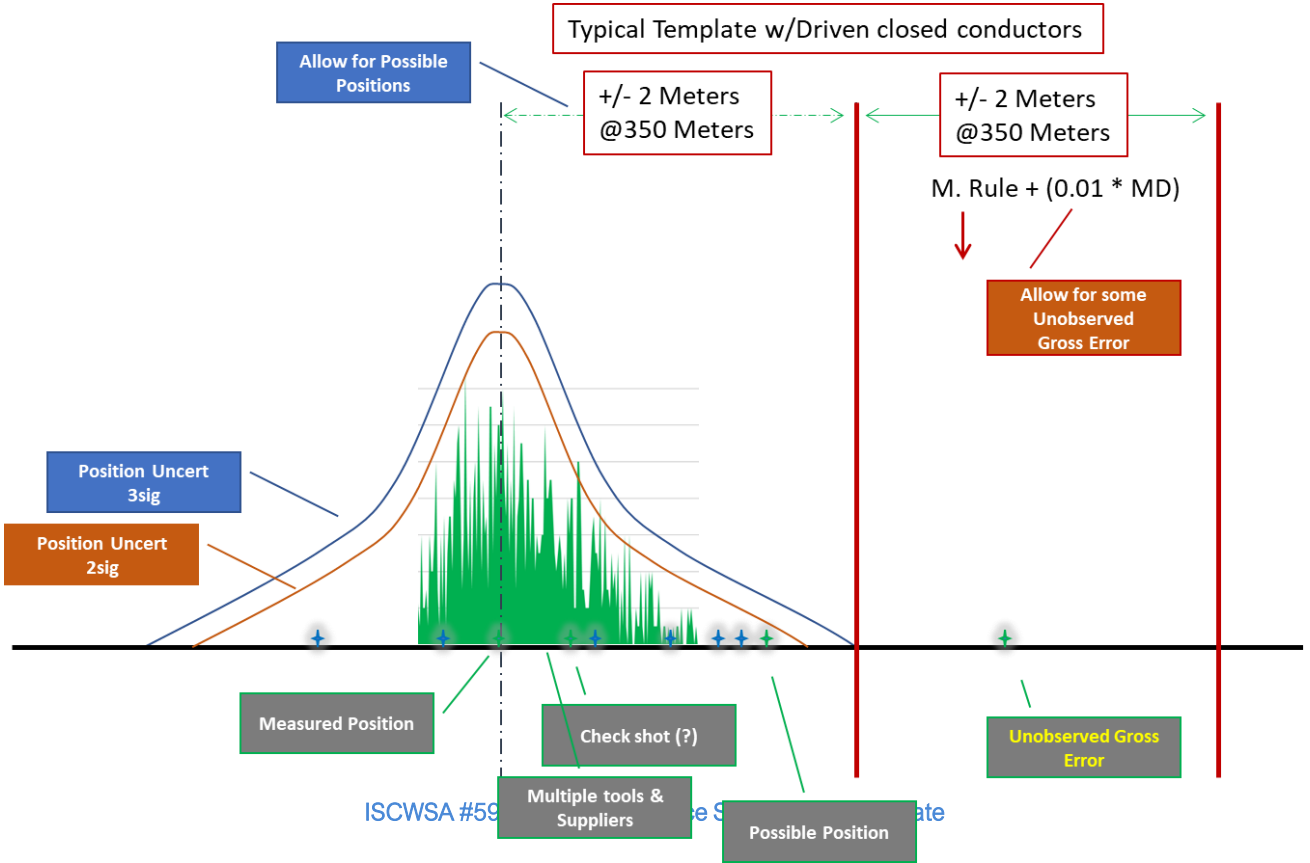
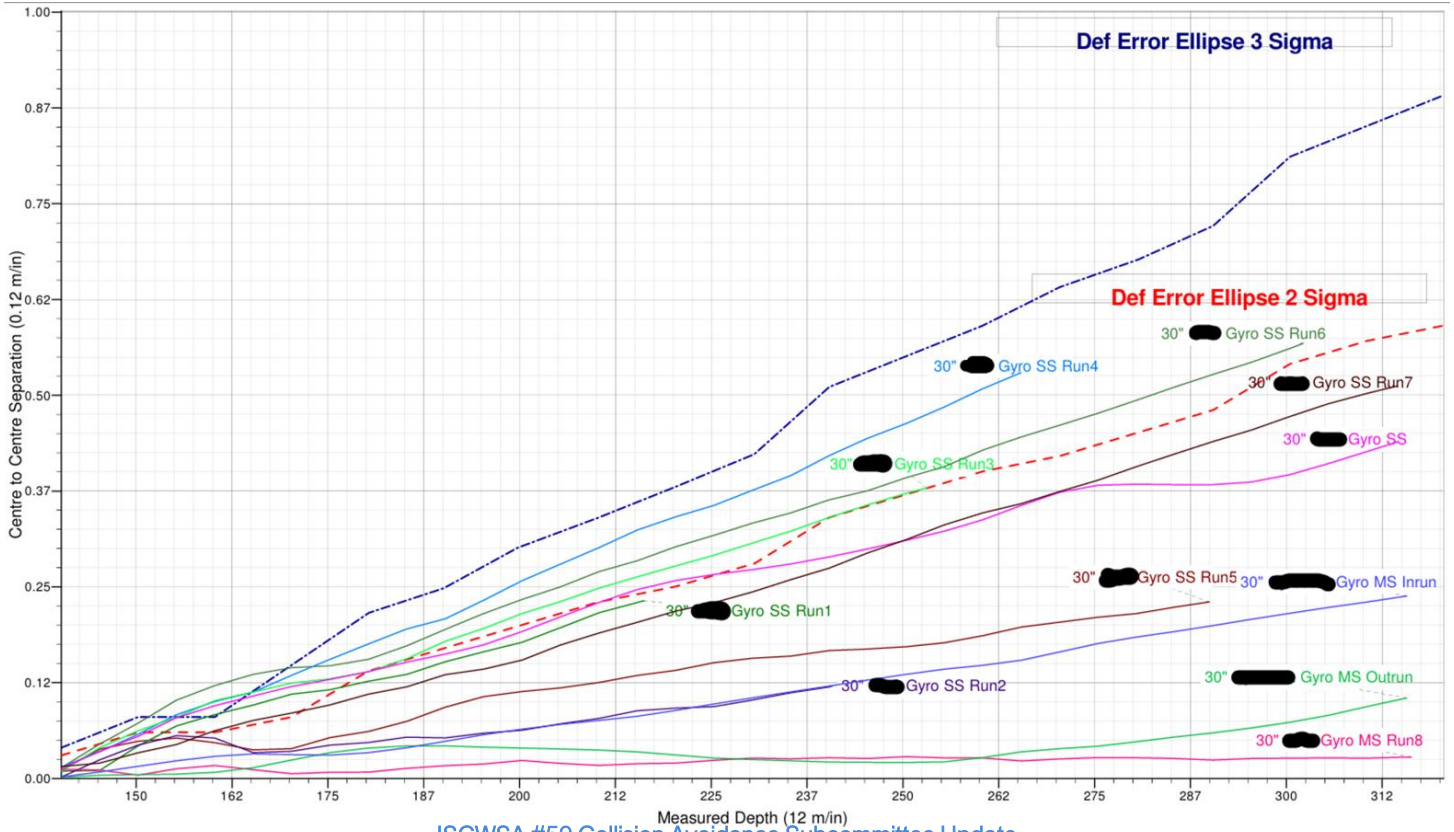
WPTS Surface Margin - BP

- Bill Allen presentation
- I will walk thru a series of slides as a working presentation where I hope to open a discussion to better answer “how do we know…” it is safe to drill ahead.
- How do we know the SM is REQUIRED or not…
- Can we do something to more tightly manage or remove SM values?


Typical Template w/Driven closed conductors
Allow for Possible Positions
+/- 2 Meters @350 Meters
+/- 2 Meters @350 Meters
M. Rule + (0.01 * MD)
Allow for some Unobserved Gross Error
Position Uncert 3sig
Position Uncert 2sig
Measured Position
Check shot (?)
Multiple tools & Suppliers
Possible Position
Unobserved Gross Error


Def Error Ellipse 3 Sigma
Def Error Ellipse 2 Sigma
30" Gyro SS Run6
30" Gyro SS Run4
30" Gyro SS Run7
30" Gyro SS
30" Gyro SS Run3
30" Gyro SS Run5
30" Gyro MS Inrun
30" Gyro SS Run1
30" Gyro MS Outrun
30" Gyro SS Run2
30" Gyro MS Run8
Centre to Centre Separation (0.12 m/in)
Measured Depth (12 m/in)
1.00
0.87
0.75
0.62
0.50
0.37
0.25
0.12
0.00
150
162
175
187
200
212
225
237
250
262
275
287
300
312

WPTS Surface Margin – Questions

- Is 3 survey systems sufficient? Too much?
- Is RIP or Chai Square sufficient?
- What about human error (typo on North Correction on Supplier software?)
- Is this evaluated at X Confidence and/or Sigma levels?
- How can this be LESS subjective (share challenge of survey system Tie-on effect)
- What about using methods like DI or Depth BIAS correction validation?
- Other concerns/thoughts?

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SPE-189654-MS Probability Of Wellbore Intercept Made Easy

Method

- Based on 2 line segment distance calculation with end limits
- Reference and offset well is broken into segments based on survey stations – assumed to be straight between stations.
- Assumption: Systematic errors dominate and there is very little random variation from station to station.
- Assumption: Uses computed error radii reported from EOU reports as Lateral / Highside and rotation. No bias.
- Distribution is Laplacian (Student 6) in inclined wellbores
- Distribution is Normal (Gaussian) in vertical wellbores

$$Formula: P = 0.5(e^{-\sqrt{2}\frac{(S-R)}{\sigma}} - e^{-\sqrt{2}\frac{(S+R)}{\sigma}})$$

Integrating the Laplace Probability Distribution to Obtain Probability of

Fig. 5 shows the method for 1D integration of the Laplace distribution. In the previous work, similar methods are used for integrating the normal probability distribution (Willamson 1998, McNair 2005).

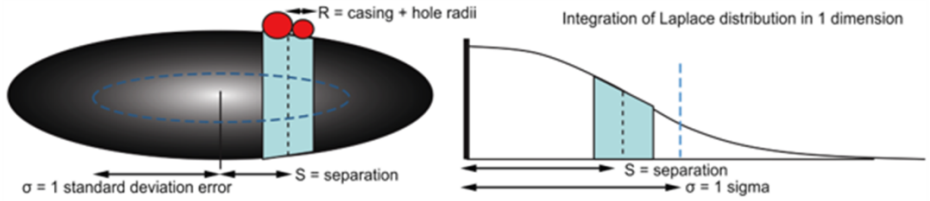


Fig. 5—Diagram of probability integration for point-to-point calculations.

Integration formula (Eq. 1) uses a function

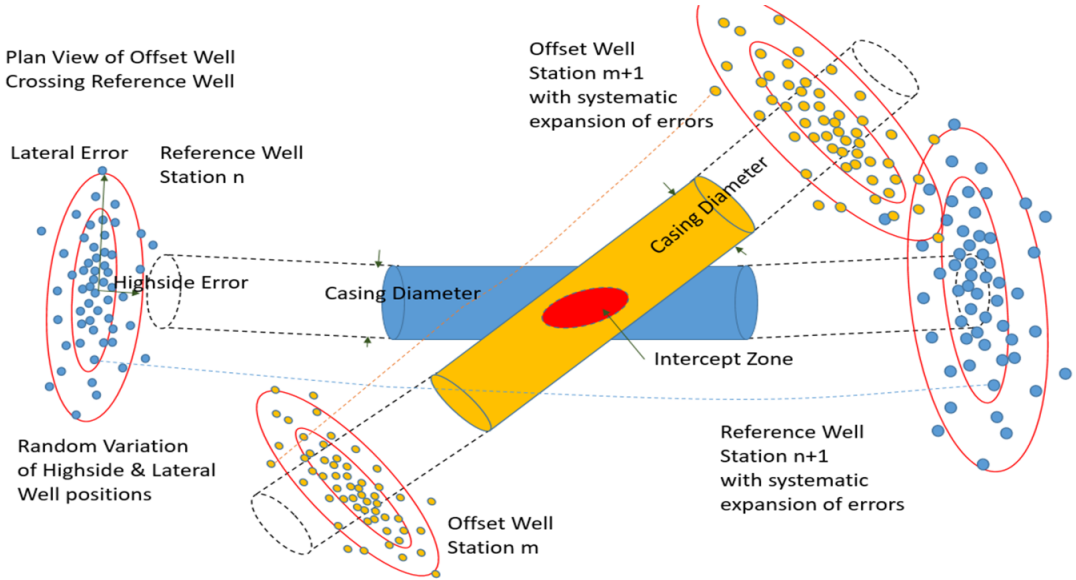
$$P = 0.5(e^{-\frac{S-R}{\sigma\sqrt{2}}} - e^{-\frac{S+R}{\sigma\sqrt{2}}}) \quad (1)$$

$$P = 0.5(e^{-\sqrt{2}\frac{S-R}{\sigma}} - e^{-\sqrt{2}(S+R)/\sigma})$$

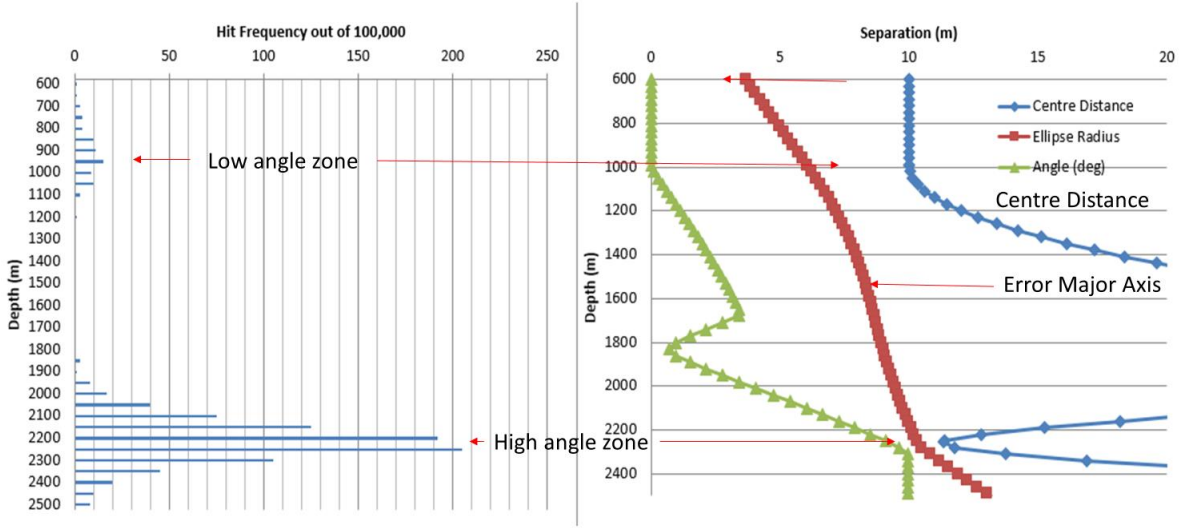
With the following nomenclature:

- P is the probability of interception as a fraction.
- Sigma (σ) is the one standard deviation of the relative error in the direction between the two wells.
- S is the separation between the two wells; this can be obtained.
- R is the sum of the radii of the offset and reference wells.

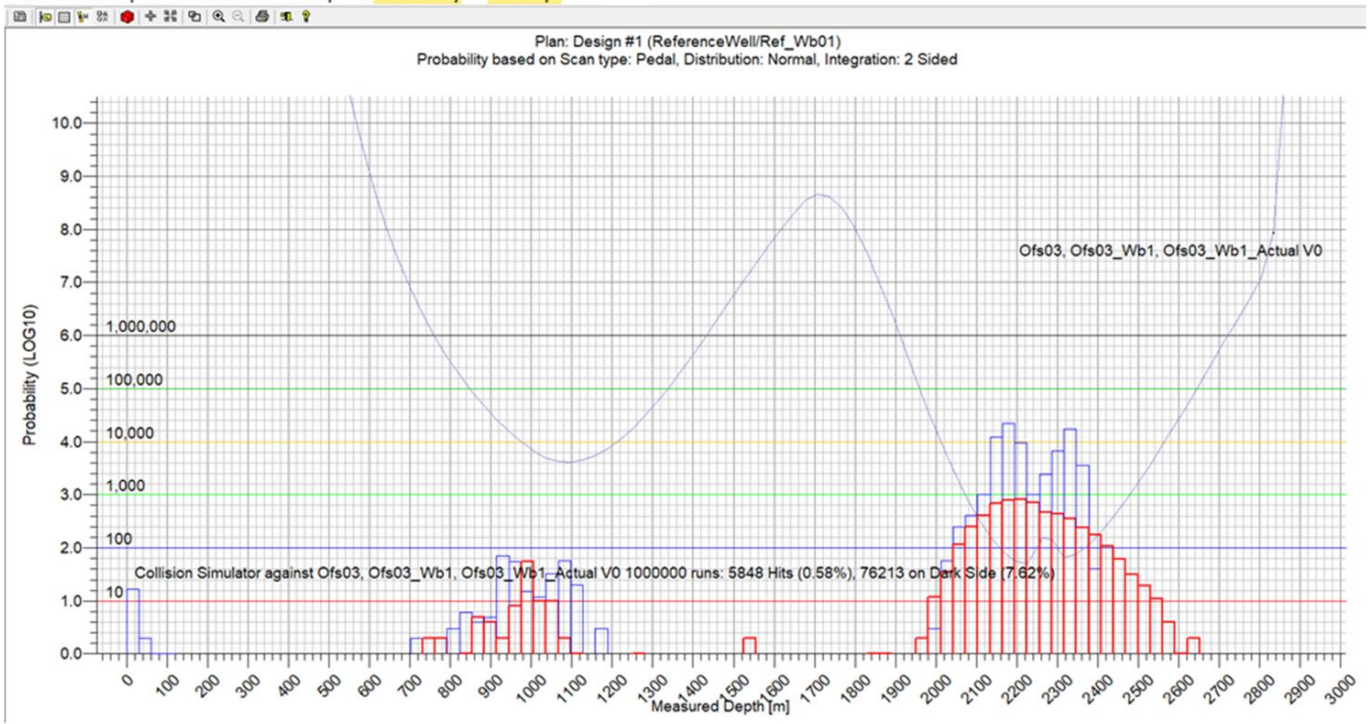
Illustration of Monte Carlo Simulator for Well Intercept



Results of Monte-Carlo Simulator for Offset 03



This is an extra plot that I added to compass. Probability of Intercept.



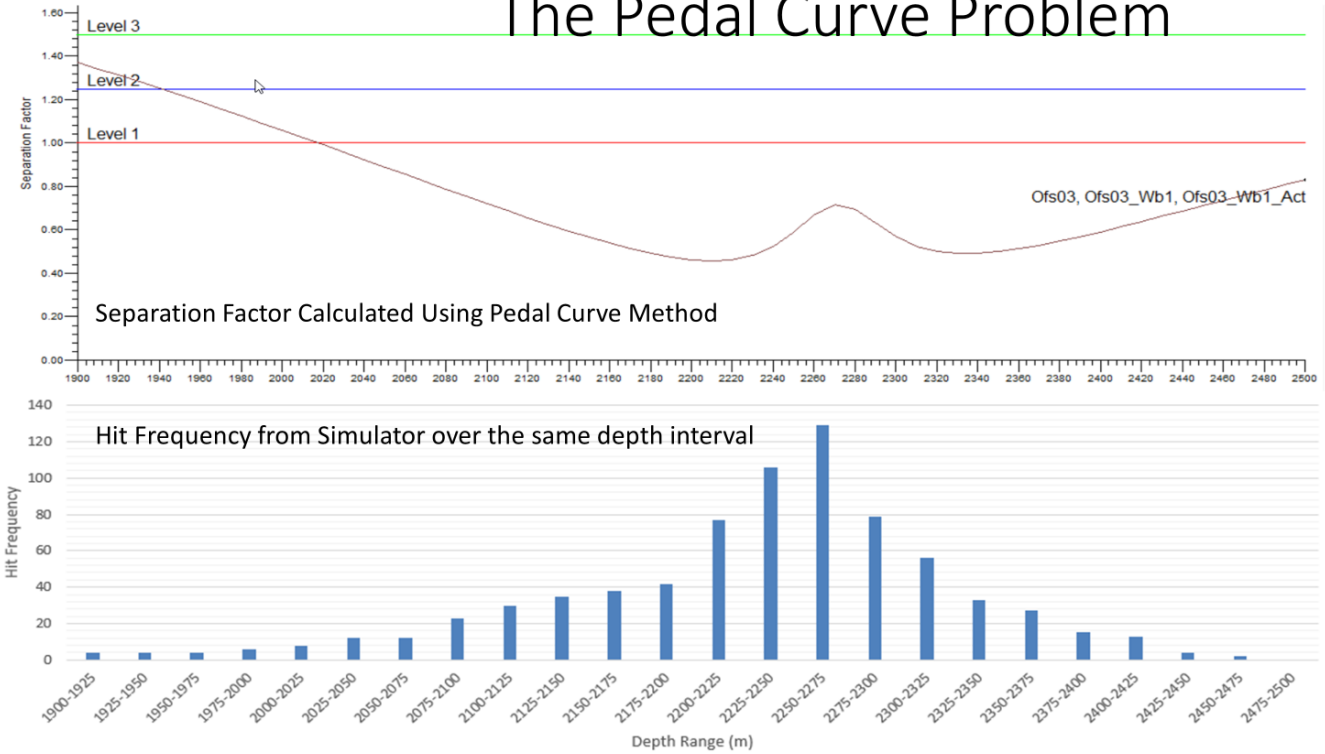
Papers for Point-to-Point Calculations

Name Paper	Title of Paper	1 or 2 sided	Pedal/Ellipse	Gaussian/ Exponential	Comment
Hugh Williamson SPE23941 1996 SPE36484 1998	Towards Risk Based Separation Rules. QRA on well collisions – Thorogood etc	2 sided	Pedal	Gaussian	Balanced?
John Bang SPE184644 2017	Quantification of Wellbore-**Collision Probability** by Novel Analytic Methods	1 or 2 sided	Pedal	Exponential	Conservative
Andy Brooks SPE116155 2008	A New Look at Wellbore **Collision Probability**	2 sided	Pedal	Gaussian	Balanced
Benny Poedjono SPE101719 2007	Well-Collision Risk in Congested Environments	1 sided	Pedal	Gaussian	Conservative
Jerry Codling	Probability of Collision made Simple	2 sided	Ellipse Separation	Exponential	

Results from Standard ISCWSA Offset wells

Offset Well	Simulator Probability	Point to Point Prob.	Angle of Intercept	Sigma Level	Separation Factor (using 3.5σ)	Comment
03	0.93%	2.50%	10	1.5-1.7	0.46	Using Pedal Curve
		1.93%	10	2.4-2.6	0.72	Using Projected Vector
04	2.55%	3.17%	1.5	1.1-1.3	0.32	Nearly parallel
06	0.034%	0.04%	180	3.5-3.6	1.00	Large Separation
09	11.0%	10.56%	90	0+/-0.15	0.0	End on Horiz. vs Vertical
10	2.10%	2.33%	30	0.9-1.1	0.27	Side-track from same well
11	8.44%	5.87%	90	0.45-0.65	0.12	End on Horiz./Horiz.

The Pedal Curve Problem

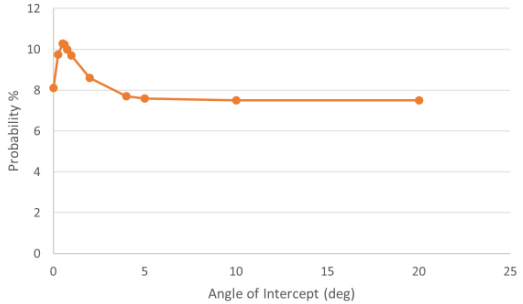


Angle of Approach

Pedal Curve based formulas assume that there is complete uncertainty in angle of approach (toolface). This is worst case and applies only to near vertical wells – as misalignment is an equal radial error.

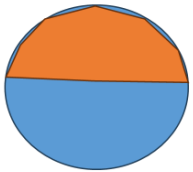
In angled intersections the uncertainty in the approach angle (toolface) is usually better than 2 deg

Ellipse separation works better in all cases.

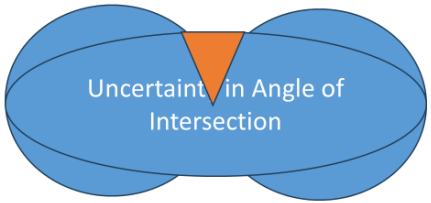


High Low – intersections…..

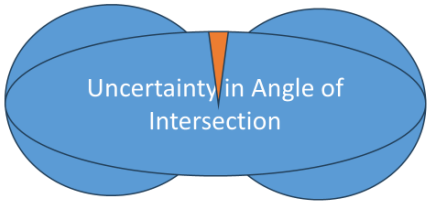
Nearly Parallel Wells - Vertical



Angle of Intercept 2-5 degrees



Angle of Intercept 5+ degrees



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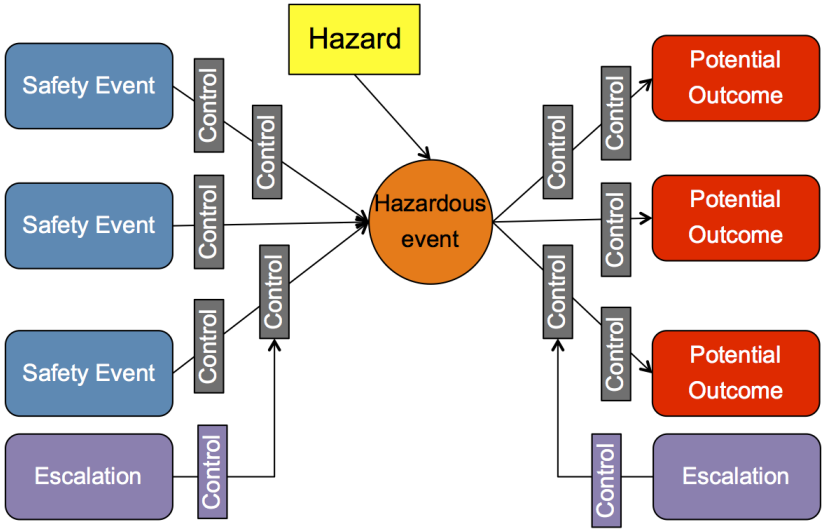
Probability Of Collision – "standardization"?

- Collision Avoidance Calculations - Current Common Practice
- Probability Of Collision Calculations - Current Common Practice
- Survey of published material
  - Spreadsheet of papers – to be posted
  - Comparison of features of calculations
    - Direct Hit vs Other Side e.g. 1-sided vs 2-sided (dark side)
    - Selection of appropriate distribution Gaussian vs Laplacian

PC Discussion

- Consensus was when looking at PC “likelihood,” need first to determine the severity of a collision to appropriately evaluate the RISK
- Define some RISK mitigation measures
- Exemption pre-planning “probability of needing an exemption?”
- PC alone is insufficient and not a direct tool

Likelihood	Consequence: Negligible 1	Minor 2	Moderate 3	Major 4	Catastrophic 5
5 Almost certain	Moderate 5	High 10	Extreme 15	Extreme 20	Extreme 25
4 Likely	Moderate 4	High 8	High 12	Extreme 16	Extreme 20
3 Possible	Low 3	Moderate 6	High 9	High 12	Extreme 15
2 Unlikely	Low 2	Moderate 4	Moderate 6	High 8	High 10
1 Rare	Low 1	Low 2	Low 3	Moderate 4	Moderate 5



Continued Working

1. Update Documentation – Bibliography / Lexicon / Merge include other groups
2. Complete reporting minimum standards
3. Sidetrack handling CA diagnostics files and Rev 5 update of benchmarks
4. Update CA Benchmark for Rev5 & WPTS
5. Update of details of CA test wells

New Initiatives

1. Collision Avoidance industry practices – Survey (to be sent)
2. CA-Survey Database Management – Recommendations (Hans Dreisig – TotalEnergies)
   - Expansion with details of other components of competent CA system
3. Recommendations on Graphics systems for CA and combined covariance representation

Thank You – Questions? Corrections?

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